COMPARISON OF TWO SEA ICE SIMULATIONS FORCED WITH ECMWF AND NCEP/NCAR REANALYSES DATA

Holger Pohlmann, Markus Harder, Thomas Martin and Peter Lemke
Institute of Marine Research at the University of Kiel,
Duesternbrooker Weg 20, D-24105 Kiel, Germany
E-mail: hpohlmann@ifm.uni-kiel.de

1. INTRODUCTION

One important application of reanalysis data is the forcing of sea ice - ocean models. In this study we investigate the implication of two reanalysis data sets with respect to sea ice extent, volume and transport which determine the oceanic surface boundary conditions and therefore the thermohaline circulation in high latitudes.

Two simulations with a dynamic-thermodynamic sea ice model applied to the Southern Ocean in the period from 1979 to 1993 are compared. In the first case, atmospheric forcing (air temperature and wind) derived from the ECMWF reanalysis (Gibson et al., 1997) is used as boundary condition (hereafter called EC-simulation). In the second case, the same atmospheric variables are derived from the NCEP/NCAR reanalysis (Kalnay et al., 1996) (hereafter called NC-simulation). All other boundary conditions are identical in both cases.

2. MODEL DESCRIPTION

The sea ice model *Kiel Sea Ice Simulation* (KISS) (Lemke et al., 1990 and Harder et al., 1999a) which is used in this study is a dynamic-thermodynamic model with a viscous-plastic rheology based on Hibler (Hibler, 1979). A prognostic snow layer is implemented in the model. The lower boundary is represented by a mixed layer model for the ocean (Niiler and Kraus, 1977).

The circumpolar model domain extends from 78.5°S to 50°S. The spatial resolution is 0.5° in latitudinal direction and 1.5° in longitudinal direction. The sea ice model uses a time step of one day.

3. FORCING DATA

The data sets of the reanalyses differ in air temperature as well as in wind speed and direction. The mean winter surface air temperature averaged over the model domain during the simulation period from the NCEP/NCAR reanalysis is 3°C below that from the ECMWF reanalysis (Figure 1). The largest differences occur in the Weddell Sea and Ross Sea with values of more than 10°C. For the wind fields the differences appear predominantly in coastal regions.

The climatological fields of precipitation and humidity are obtained from the ECMWF reanalysis and were prescribed as an annual cycle. Also averaged with the same temporal resolution total cloud cover was derived from the *International Satellite Cloud Climatology Project* (ISCCP) (Schiffer and Rossow, 1983). Oceanic forcing data are used as climatological mean values. Ocean currents are obtained from the *Ocean Circulation and Climate Advanced Modelling Project* (OCCAM) (Webb et al., 1998) from the *Southampton Oceanography Center* (SOC). Ocean temperature and salt content are derived from the *Southern Ocean Atlas* (SOA) (Olbers et al., 1992) published by the *Alfred-Wegener-Institut/Bremerhaven* (AWI).

4. RESULTS

The ice extent is one of the simulated ice properties. We use the definition of ice extent as the area

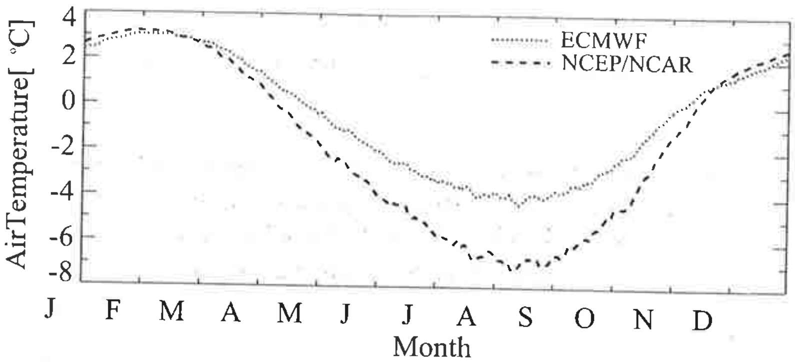

Figure 1: *Mean air temperature of the model domain during the simulation period (1979-1993) from the ECMWF reanalysis (dotted line) and NCEP/NCAR reanalysis (dashed line).*

with an ice concentration of more than 15%. The ice extent is highly variable in the Southern Ocean. It varies from 3 million km^2 in summer to 19 million km^2 in winter as satellite observations (Gloersen and Campbell, 1992) from *Scanning Multichannel Microwave Radiometer* (SMMR) and *Special Sensor Microwave/Imager* (SSMI) produced by the *National Snow and Ice Data Center* (NSIDC) measurements show. The annual variability is well represented in both simulations (Figure 2).

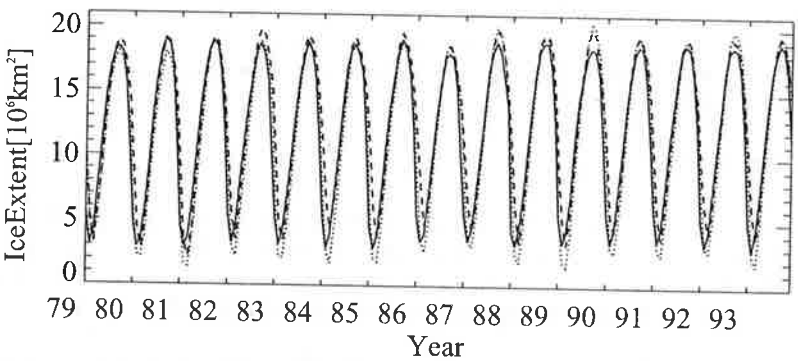

Figure 2: *Comparison of ice extent from SMMR and SSMI satellite observations (solid curve) with ice extent of the EC-simulation (dotted line) and NC-simulation (dashed line).*

The winter ice extent agrees well with results from remote sensing techniques but differences appear in summer. The ice extent of the EC-simulation is in this season too low and in the NC-simulation it is too large (Figure 3). Due to the lower air temperatures in the NC-forced model the winter ice thickness is enhanced. After melting in spring and summer there is more ice left which leads to the larger summer ice extent in the NC-simulation.

Regional differences of the simulated ice extent compared to the observations occur especially in summer. For example, there is less ice in both simulations eastward of the northern end of the Antarctic Peninsula. The so-called "barrier winds" of both reanalyses are too weak in this region. In observations (Schwerdtfeger, 1984) the preferred direction has been more southerly than in the reanalyses. The topography of the northern Antarctic Peninsula is smoothed in both reanalyses due to the coarse spatial resolution of the reanalysis models. Therefore the barrier winds cannot develop in this region (Windmueller, 1997).

The ice volume of the NC-simulation is larger than that of the EC-simulation due to the lower temperatures in the NC-forcing (Figure 4). Considerably more salt is released in the ocean in the NC-simulation as compared to the EC-simulation. However, it is important for global ocean circulation models to know the real quantity of released salt to force the thermohaline circulation of the deep ocean (Harder and Fischer, 1999b).

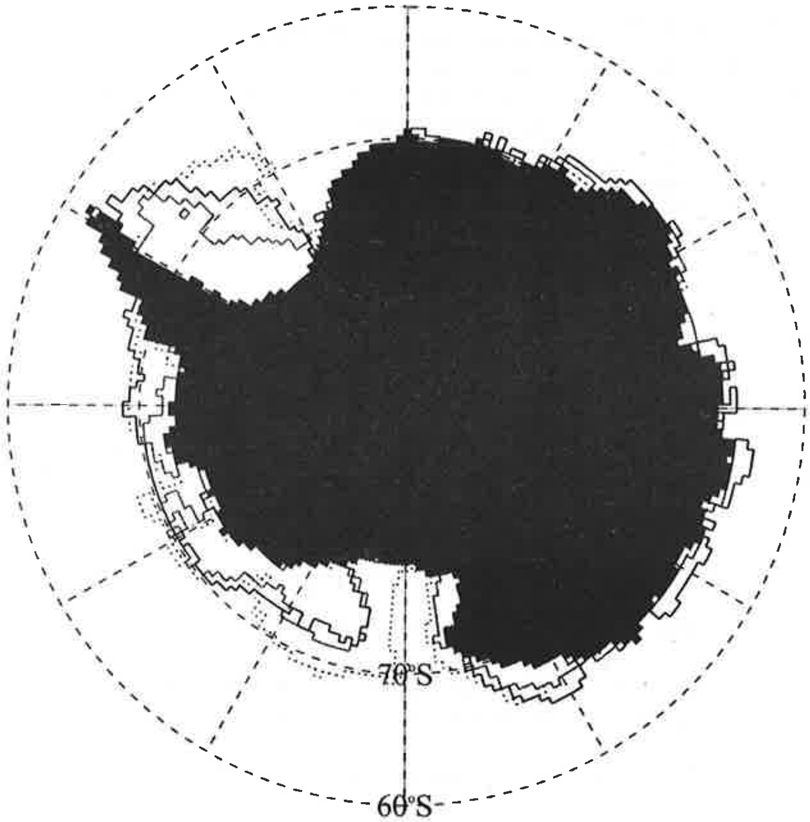

Figure 3: *Minimum ice extent averaged in the simulation period from SMMR and SSMI satellite observations (solid black line) compared to the ice extent of the EC-simulation (solid grey line) and the NC-simulation (dotted line).*

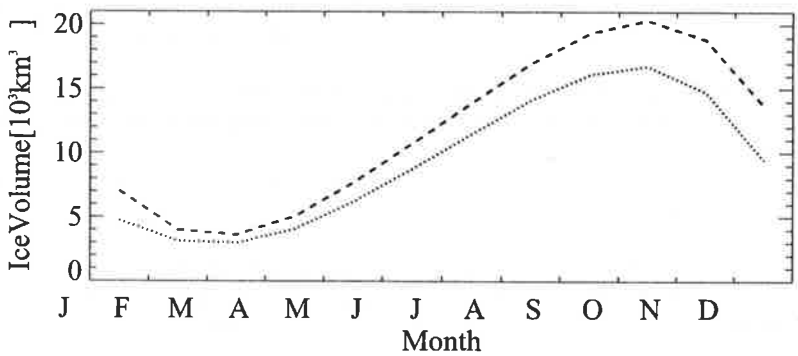

Figure 4: *Mean ice volume during the simulation period from the EC-simulation (dotted line) and NC-simulation (dashed line).*

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